RADAR Titan Flyby during S29/T29

R. West

May 16, 2007

- Sequence: s29
- Rev: 043
- Observation Id: t29
- Target Body: Titan
- Data Take Number: 127
- PDT Config File: S29_ssup_psiv1_070131_pdt.cfg
- SMT File: s29_smt_070208.rpt
- PEF File: z0290c.pef

1 Introduction

This memo describes the Cassini RADAR activities for the T29 Titan flyby. This SAR data collection occurs during the s29 sequence of the Saturn Tour. This is a full radar pass. The SAR profile is pushbroomed on both ends. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidlines for preparing the RADAR IEB.

2 CIMS and Division Summary

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design. Table 1 shows the CIMS request summary for this observation. Although the CIMS requests show Low-SAR intervals, in reality the radar will be operated in Hi-SAR mode through most of this flyby.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Table 3 shows a summary of some key geometry values for

CIMS ID	Start	End	Duration	Comments
043TI_T29WARMUP001_RIDER	2007-116T16:41:29	2007-116T19:41:29	03:00:0.0	Warmup for T29 inbound radiometry. REU bits included.
043TI_T29INSCAT001_PRIME	2007-116T19:41:29	2007-116T20:39:29	00:58:0.0	Mid latitude scatterometry of unique terrain coverage of Titan. Acceptable alternative to T28 or T30. REU bits included.
043TI_TI29INALT001_PRIME	2007-116T21:01:29	2007-116T21:15:29	00:14:0.0	Altimetry taken during the inbound leg of the T29 flyby. REU bits included.
043TI_TI29ILSAR001_PRIME	2007-116T21:15:29	2007-116T21:24:29	00:09:0.0	Low resolution SAR imaging on the inbound leg of T29. REU bits included.
043TI_TI29HISAR001_PRIME	2007-116T21:24:29	2007-116T21:38:29	00:14:0.0	High resolution SAR imaging of T29 during the C/A flyby.
043TI_TI29OLSAR001_PRIME	2007-116T21:38:29	2007-116T21:47:29	00:09:0.0	Low resolution SAR imaging on the outbound leg of T29. REU bits included.
043TI_TI29OTALT001_PRIME	2007-116T21:47:29	2007-116T22:01:29	00:14:0.0	Altimetry taken during the outbound leg of the T29 flyby. REU bits included.
043TI_TI29OSCAT001_PRIME	2007-116T22:25:29	2007-116T22:48:29	00:23:0.0	Mid latitude scatterometry of unique terrain coverage of Titan. Acceptable alternative to T28 or T30. REU bits included.
043TI_T29OUTRAD001_PRIME	2007-116T22:48:29	2007-117T02:21:29	03:33:0.0	Outbound radiometry of unique terrain at mid latitudes. Acceptable alternative to T28. REU bits included.

Table 1: t29 CIMS Request Sequence

Division	Name	Start	Duration	Data Vol	Comments
a	Warmup	-4:50:0.0	03:00:0.0	2.7	Warmup
b	standard_scatterometer_inbound	-1:50:0.0	00:57:0.0	102.6	Inbound scatterometry raster
c	standard_altimeter_inbound	-0:53:0.0	00:23:0.0	41.4	Inbound bonus altimetry
d	standard_altimeter_inbound	-0:30:0.0	00:09:30.0	19.9	Inbound altimetry
e	standard_sar_hi	-0:20:30.0	00:00:30.0	1.5	Hi-SAR Turn transition, beam 3 only
f	standard_sar_hi	-0:20:0.0	00:04:0.0	56.6	Hi-SAR Turn transition, 5 beams
g	standard_sar_hi	-0:16:0.0	00:32:0.0	453.1	Hi-SAR main swath
h	standard_sar_low_inbound	00:16:0.0	00:00:12.0	2.6	Outbound Low-SAR ping-pong
i	standard_sar_hi	00:16:12.0	00:00:12.0	2.9	Outbound Hi-SAR ping-pong
j	standard_sar_low_inbound	00:16:24.0	00:00:12.0	2.6	Outbound Low-SAR ping-pong
k	standard_sar_hi	00:16:36.0	00:00:12.0	2.9	Outbound Hi-SAR ping-pong
l	standard_sar_low_inbound	00:16:48.0	00:00:12.0	2.6	Outbound Low-SAR ping-pong
m	standard_sar_hi	00:17:0.0	00:00:12.0	2.9	Outbound Hi-SAR ping-pong
n	standard_sar_low_inbound	00:17:12.0	00:00:12.0	2.6	Outbound Low-SAR ping-pong
o	standard_sar_hi	00:17:24.0	00:00:12.0	2.9	Outbound Hi-SAR ping-pong
p	standard_sar_low_inbound	00:17:36.0	00:00:12.0	2.6	Outbound Low-SAR ping-pong
q	standard_sar_hi	00:17:48.0	00:00:12.0	2.9	Outbound Hi-SAR ping-pong
r	standard_sar_low_outbound	00:18:0.0	00:00:30.0	6.5	Outbound Low-SAR ping-pong
s	standard_sar_hi	00:18:30.0	00:01:0.0	3.0	Hi-SAR turn transition to altimetry, B3 only
t	standard_altimeter_outbound	00:19:30.0	00:10:30.0	22.1	Outbound altimetry
u	standard_altimeter_outbound	00:30:0.0	00:21:48.0	39.2	Outbound bonus altimetry
v	standard_scatterometer_outbound	00:51:48.0	00:02:42.0	4.9	Outbound scatterometry turn to imaging
w	scatterometer_imaging	00:54:30.0	00:03:42.0	16.7	Outbound scatterometer imaging
x	scatterometer_imaging	00:58:12.0	00:06:18.0	28.3	Outbound scatterometer imaging
y	scatterometer_imaging	01:04:30.0	00:06:48.0	30.6	Outbound scatterometer imaging
z	scatterometer_imaging	01:11:18.0	00:03:12.0	14.4	Outbound scatterometer imaging
lbrace	standard_scatterometer_outbound	01:14:30.0	00:02:30.0	4.5	Outbound scatterometry turn from imaging
vbar	standard_radiometer_outbound	01:17:0.0	03:33:0.0	12.7	Outbound radiometry scans
Total				887.8	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	99543	off target	0.13	off target
b	36529	36529	0.05	234
c	16643	16643	0.02	489
d	8745	8745	0.01	839
e	5605	5605	0.01	1165
f	5445	5445	0.01	1188
g	4193	4273	0.01	1409
h	4193	4275	0.01	1409
i	4254	4339	0.01	1396
j	4315	4403	0.01	1384
k	4377	4468	0.01	1372
l	4438	4533	0.01	1360
m	4500	4599	0.01	1348
n	4562	4664	0.01	1336
o	4624	4730	0.01	1324
p	4686	4797	0.01	1313
q	4749	4863	0.01	1302
r	4811	4928	0.01	1291
s	4968	5050	0.01	1264
t	5285	5285	0.01	1212
u	8744	8745	0.01	839
v	16225	16225	0.02	500
w	17162	17558	0.02	476
x	18447	19069	0.03	446
y	20639	21220	0.03	402
z	23008	23523	0.03	364
lbrace	24124	24995	0.03	348
vbar	24996	off target	0.03	off target

Table 3: Division geometry summary. Values are computed at the start of each division. B3 Doppler spread is for two-way 3-dB pattern. B3 size is the one-way 3-dB beamwidth

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	-480.0	-290.0	yes	IEB Trigger time is usually later than this
end_time (min)	-300.0	-110.0	yes	
time_step (s)	2700.0	3600.0	yes	Used by radiometer only modes - saves commands
bem	00100	11111	yes	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.248	no	Kbps - actual data rate may be less
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: t29 Div a Warmup block

each division. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

3 Special Features of this Pass

T29 has one high altitude imaging segment in place of the usual outbound scatterometry scan. The outbound high altitude imaging segment consists of three scan lines in the north polar area with a little overlap over the T25 outbound high altitude imaging segment.. The T29 SAR swath is left looking and will overlap with the upcoming T28 SAR swath in the north polar area.

4 Warmup and Radiometry

The radar warmup rider begins at 2007-04-26T16:41:29.000 (-04:51:28.8). During the warmup, the IEB will be set to collect 4-second radiometer data on all 5 beams as shown in table 4. There are no inbound radiometry scans. Div | covers the outbound radiometry scans with 1-second radiometry.

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	120.0	77.0	yes	
end_time (min)	300.0	290.0	yes	
time_step (s)	2700.0	3600.0	yes	Used by radiometer only modes
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.992	0.992	no	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 5: t29 Div vbar standard_radiometer_outbound block

5 Div's B,V, {: Regular Scatterometry

The inbound regular scatterometry raster scan is covered by div B. The inbound scan is all at high incidence angles or high altitude and uses the 9 dB attenuator throughout. The turns to and from high altitude imaging in the outbound scatterometry segment are covered by div's V and {.

Scatterometer mode operations use a transmit-receive window offset (TRO) of 6 which makes the echo window 6 PRI's longer than the number of pulses transmitted. This is done to increase the valid time for an instruction by letting the pulse echos walk through the longer echo window before the range-gate needs to be updated. This is particularly important during Titan scatterometry raster scans where the number of instructions needed to track the varying range can exceed the number available if a smaller TRO value is used. The positive TRO value also guarantees noise-only data in each burst which eliminates the need to insert special noise-only bursts. The PRF of 1.2 KHz is high enough to cover the doppler spread within beam 3, so doppler sharpening could be performed.

6 Div's W-Z: Scatterometry Imaging

The T29 outbound high altitude imaging segment is very similar to the T25 outbound imaging segment. Both are in the north polar area, and both push the performance limits with three scan lines. The outbound imaging segment starts at 54.5 minutes and ends at 74.5 minutes from closest approach. and then decreased to 9 dB once the incidence angle rises up again. Div's W-Z shown in tables 8 and 9 provide high altitude imaging data. The separate divisions are used to track PRF variations needed to keep range and doppler ambiguities approximately evenly balanced. The three scan lines cover a region next to the T25 swath in the north polar area. This area will not be imaged otherwise during the Tour.

The imaging divisions (W-Z) push against the 7% duty cycle limit, the 32 Kbyte size of the science data buffer, the round trip time limitation, and the number of pulses that the ESS can put out. To allow the best possible azimuth resolution, the duty cycle is reduced to allow a longer pulse train while still remaining below the 7% duty cycle limit. This trades SNR for resolution as was done in T19. Resolution in these segments will be about 2.5 km by 3.5 km.

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	-110.0	no	
end_time (min)	varies	-53.0	no	
time_step (s)	don't care	14.0	no	Set by valid time calculation
bem	00100	00100	no	
baq	5	5	no	5 - 8 bits straight
csr	0	0	no	0 - No auto-gain, fixed attenuator set to avoid clipping
noise_bit_setting	4.0	4.0	no	9 dB attenuator
dutycycle	0.70	0.70	no	
prf (Hz)	1200	1200	no	
tro	6	6	no	
number_of_pulses	8	8	no	
n_bursts_in_flight	1	1	no	
percent_of_BW	100.0	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	30.000	30.000	no	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 6: t29 Div b standard_scatterometer_inbound block

6.1 PRF and Incidence Angle Choices

Incidence angle variation during the timaging segment is moderate with higher values than used in normal SAR imaging. (see Figs 1) The PRF value is set to 1 KHz with a pulse duty cycle of 0.35, or 600 Hz with a pulse duty cycle of 0.16 in the imaging divisions. These PRF values provide for a reasonable balance between range and doppler ambiguities throughout the imaging rasters. Pixel structure is good in the southern part of the imaged area which is close to the iso-doppler point where iso-range and iso-doppler lines are nearly orthogonal. At the north edge of the scan lines, the angle between iso-range and iso-doppler lines is allowed to drop to about 45 degrees. For more technical details on range and doppler ambiguities, refer to the discussion in the T19 sequence design memo.

6.2 SAR-style Scatterometer Resolution Performance

Since SAR processing will be applied to this segment, the effective resolution can be calculated from the same equations,

$$\delta R_g = \frac{c}{2 B_r \sin\theta_i}, \tag{1}$$

$$\delta x = \frac{\lambda R}{2 \tau_{rw} v \sin\theta_v}, \tag{2}$$

where δR_g is the projected range resolution on the surface, c is the speed of light, B_r is the transmitted chirp bandwidth, θ_i is the incidence angle, δx is the azimuth resolution on the surface, λ is the transmitted wavelength, R is the slant range, τ_{rw} is the length of the receive window, v is the magnitude of the spacecraft velocity relative to the target body, and θ_v is the angle between the velocity vector and the look direction. Figure **??** shows the results from these equations for division E and figure **??** shows the results for division Z. The calculations are performed for the boresight of beam 3 which is the center of the swath.

Name	Nominal	v	lbrace	Mismatch	Comments
mode	scatterometer	scatterometer	scatterometer	no	
start_time (min)	varies	51.8	74.5	no	
end_time (min)	varies	54.5	77.0	no	
time_step (s)	don't care	8.0	6.0	no	Set by valid time calculation
bem	00100	00100	00100	no	
baq	5	5	5	no	5 - 8 bits straight
csr	0	0	0	no	0 - No auto-gain, fixed attenuator set to avoid clipping
noise_bit_setting	4.0	4.0	4.0	no	9 dB attenuator
dutycycle	0.70	0.70	0.70	no	
prf (Hz)	1200	1200	1200	no	
tro	6	6	6	no	
number_of_pulses	8	8	8	no	
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	30.000	30.000	30.000	no	
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 7: t29 Div vlbrace standard_scatterometer_outbound block

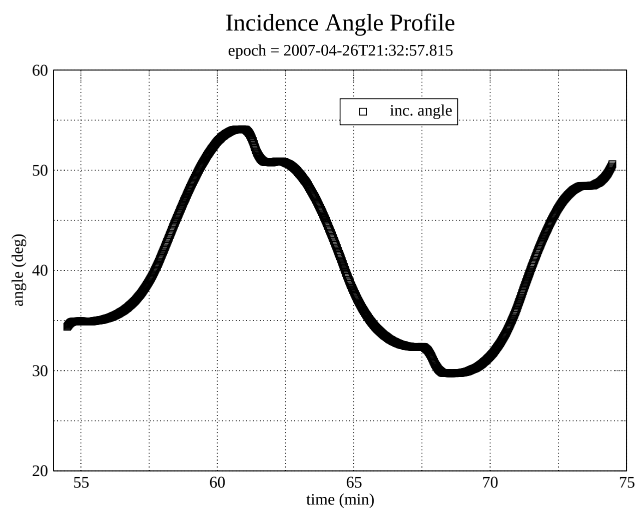

Figure 1: Incidence angle variation during Div's W-Z

Name	Nominal	w	x	Mismatch	Comments
mode	scatterometer	scatterometer	scatterometer	no	
start_time (min)	varies	54.5	58.2	no	
end_time (min)	varies	58.2	64.5	no	
time_step (s)	varies	6.0	6.0	no	
bem	00100	00100	00100	no	
baq	0	0	0	no	8-2 used to increase looks and duty cycle - hence SNR
csr	0	0	0	no	0 - fixed attenuator
noise_bit_setting	4.0	4.0	4.0	no	9 dB attenuator
dutycycle	0.35	0.35	0.16	yes	
prf (Hz)	1000	1000	600	yes	1000 Hz is typical, set to balance range/doppler ambiguities
tro	6	6	6	no	
number_of_pulses	100	98	70	yes	100 is typical, set to fill echo buffer/round trip time
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	82.000	75.000	75.000	yes	82 is typical, set to use available data volume
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 8: t29 Div wx scatterometer_imaging block

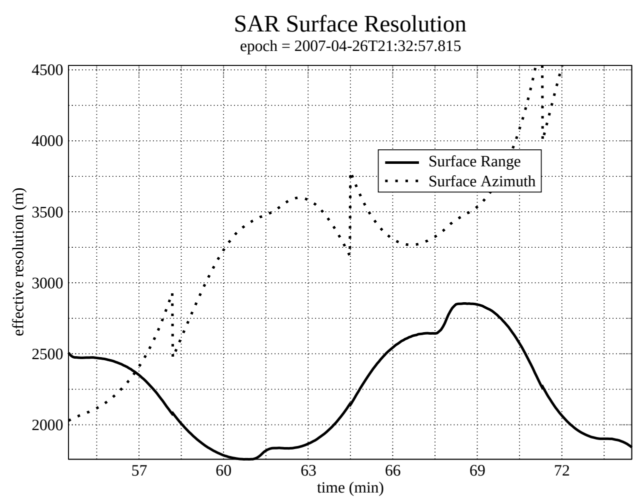

Figure 2: Div W-Z: Projected range and azimuth resolution. These values are computed from the IEB parameters.

Name	Nominal	y	z	Mismatch	Comments
mode	scatterometer	scatterometer	scatterometer	no	
start_time (min)	varies	64.5	71.3	no	
end_time (min)	varies	71.3	74.5	no	
time_step (s)	varies	6.0	6.0	no	
bem	00100	00100	00100	no	
baq	0	0	0	no	8-2 used to increase looks and duty cycle - hence SNR
csr	0	0	0	no	0 - fixed attenuator
noise_bit_setting	4.0	4.0	4.0	no	9 dB attenuator
dutycycle	0.35	0.35	0.16	yes	
prf (Hz)	1000	1000	600	yes	1000 Hz is typical, set to balance range/doppler ambiguities
tro	6	6	6	no	
number_of_pulses	100	98	70	yes	100 is typical, set to fill echo buffer/round trip time
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	82.000	75.000	75.000	yes	82 is typical, set to use available data volume
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 9: t29 Div yz scatterometer_imaging block

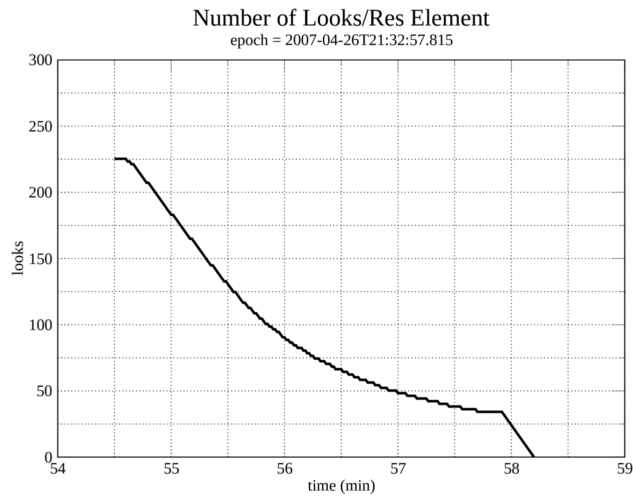

Figure 3: Div W: Number of looks. These values are computed from the IEB parameters.

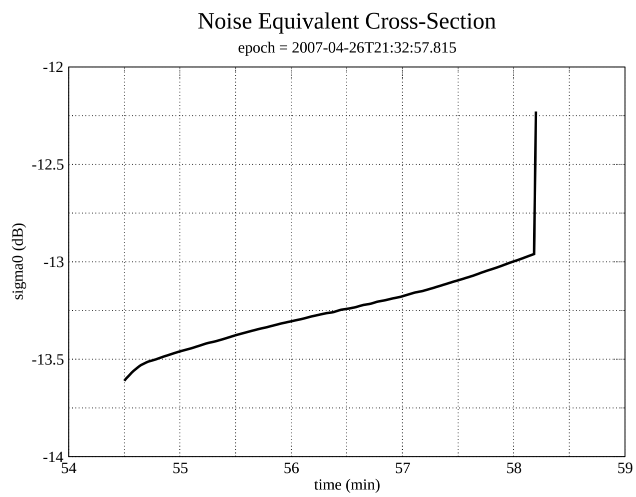

Figure 4: Div W: Noise equivalent σ_0. These values are computed from the IEB parameters.

6.3 SNR and Looks

In scatterometer mode the noise equivalent σ_0 for beam 3 will be generally better than -8 dB in these imaging segments. The number of looks varies from a low around 40 to above 100. Looks have been sacrificed in these segments to obtain more coverage area. 8-2 BAQ is used to get more looks out of available data volume.

The resolution of this observation has been improved at the expense of SNR by reducing the pulse duty cycle below 70%, and then increasing the number of pulses until the round trip time or the science data buffer is filled. The ESS limit on the number of pulses also has reduced the duty cycle to permit filling the round trip time or buffer.

7 Div's C,D,T,U: Altimetry

The parameters used by the main altimeter segments are shown in tables 10 and 11. The higher altitude divisions (C and U) cover the bonus altimeter segments where the spacecraft is nadir pointed while transitioning from thrusters to momentum wheel attitude control. The IEB parameters are the same as the regular altimetry segments.

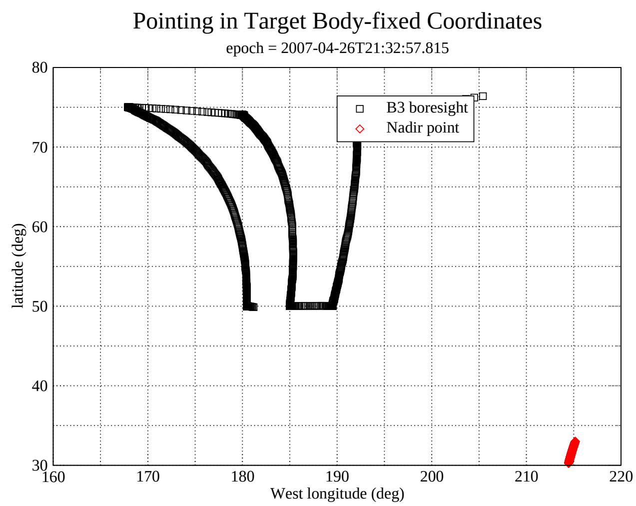

Figure 5: Outbound Scatterometry scan in target body-fixed coordinates

Name	Nominal	c	d	Mismatch	Comments
mode	altimeter	altimeter	altimeter	no	
start_time (min)	-30.0	-53.0	-30.0	yes	
end_time (min)	-19.0	-30.0	-20.5	yes	
time_step (s)	don't care	12.0	10.0	no	Set by valid time calculation
bem	00100	00100	00100	no	
baq	7	7	7	no	7 - 8 to 4
csr	8	8	8	no	8 - auto gain
noise_bit_setting	2.3	2.3	2.3	no	
dutycycle	0.73	0.73	0.73	no	
prf (Hz)	5000	5000	5000	no	
tro	don't care	-6	-6	no	auto set to -6 except interleaved bursts where +6 is used
number_of_pulses	21	21	21	no	
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	30.000	30.000	35.000	yes	
interleave_flag	on	on	on	no	
interleave_duration (min)	varies	14.0	7.0	no	

Table 10: t29 Div cd standard_altimeter_inbound block

Name	Nominal	t	u	Mismatch	Comments
mode	altimeter	altimeter	altimeter	no	
start_time (min)	19.0	19.5	30.0	yes	
end_time (min)	30.0	30.0	51.8	yes	
time_step (s)	don't care	12.0	16.0	no	Set by valid time calculation
bem	00100	00100	00100	no	
baq	7	7	7	no	7 - 8 to 4
csr	8	8	8	no	8 - auto gain
noise_bit_setting	2.0	2.3	2.3	yes	
dutycycle	0.73	0.73	0.73	no	
prf (Hz)	5000	5000	5000	no	
tro	don't care	-6	-6	no	auto set to -6 except interleaved bursts where +6 is used
number_of_pulses	21	21	21	no	
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	85.000	35.000	30.000	yes	
interleave_flag	on	on	on	no	
interleave_duration (min)	varies	7.0	14.0	no	

Table 11: t29 Div tu standard_altimeter_outbound block

8 Div's E-S: SAR Imaging

Div's E and S cover the turn transitions with beam 3 only imaging. The data rate has been reduced to 50 Kbps to conserve data volume. This should still provide enough looks during the turn transition because only one beam is used. The SAR swath is pushbroomed at both ends. Div's H-Q ping-pong back and forth every 12 seconds between Hi-SAR and Low-SAR with overlapping pixels. This provides a small increase in image quality since the two modes provide rectangular pixels with the short side in different directions. Div G covers the 32 minutes centered on closest approach. Hi-SAR is used throughout to obtain the best resolution possible. Targetting of the outbound pushbroom profile ends at +18.5 minutes. Table 12 shows the standard Hi-SAR divisions, table 13 shows two representative Low/Hi-SAR ping pong divisions, and table 14 shows the B3 only Hi-SAR divisions at the ends. The left look option is selected here to produce a swath that will overlap extensively with the planned T28 swath (also left look).

8.1 PRF and Incidence Angle Profiles

The PRF profile and incidence angle profile (Fig. 6) are optimized for maximum usuable imaging coverage. The Ta profiles were produced for a 950 km flyby which is the most common SAR flyby altitude. The T3 profiles were optimized for a 1500 km flyby. The T29 flyby will be close to 1000 km altitude, and the lower altitude profile used at Ta will be used again here. The optimized profile maximizes usable cross-track width while avoiding gaps in the imaging swath. Unlike some previous SAR imaging passes, this pass will not include any PRF hopping which has not proven necessary.

8.2 SAR Resolution Performance

For all of the SAR divisions the effective resolution can be calculated from the same equations used in the high-altitude imaging discussion. Figure 8 shows the results from these equations using the parameters from the IEB as generated by RMSS. The calculations are performed for the boresight of beam 3 which is the center of the swath.

Name	Nominal	Actual	Mismatch	Comments
mode	sarh	sarh	no	
start_time (min)	-6.0	-16.0	yes	
end_time (min)	6.0	16.0	yes	
time_step (s)	don't care	8.0	no	Set by valid time calculation unless negative, then time_step is used instead
bem	11111	11111	no	
baq	0	0	no	0 - 8 to 2
csr	8	8	no	8 - auto gain
noise_bit_setting	3.0	3.4	yes	
dutycycle	0.70	0.70	no	
prf (Hz)	don't care	0	no	RMSS follows profile
tro	don't care	0	no	
number_of_pulses	don't care	0	no	RMSS fills round trip time
n_bursts_in_flight	1	1	no	
percent_of_BW	100.0	99.0	yes	
auto_rad	off	off	no	Set off for SAR modes to allow minimum burst time
rip (ms)	34.0	34.0	no	Calculated from radiometer calibration for prior observations
max_data_rate	255.000	236.000	yes	8 to 2 reduces max data rate possible
interleave_flag	on	off	yes	
interleave_duration (min)	varies	10.0	no	

Table 12: t29 Div g standard_sar_hi block

Name	Nominal	h	i	Mismatch	Comments
mode	sarl	sarl	sarh	yes	
start_time (min)	-19.0	16.0	16.2	yes	
end_time (min)	-6.0	16.2	16.4	yes	
time_step (s)	don't care	6.0	6.0	no	Set by valid time calculation
bem	11111	11111	11111	no	
baq	0	0	0	no	0 - 8 to 2
csr	8	0	0	yes	8 - auto gain
noise_bit_setting	3.0	2.9	3.4	yes	
dutycycle	0.70	0.70	0.70	no	
prf (Hz)	don't care	0	0	no	RMSS follows profile
tro	don't care	0	0	no	
number_of_pulses	don't care	0	0	no	RMSS fills round trip time
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	on	off	off	yes	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	255.000	215.000	238.000	yes	8 to 2 reduces max data rate possible
interleave_flag	on	off	off	yes	
interleave_duration (min)	varies	10.0	10.0	no	

Table 13: t29 Div hi standard_sar_low_inbound block

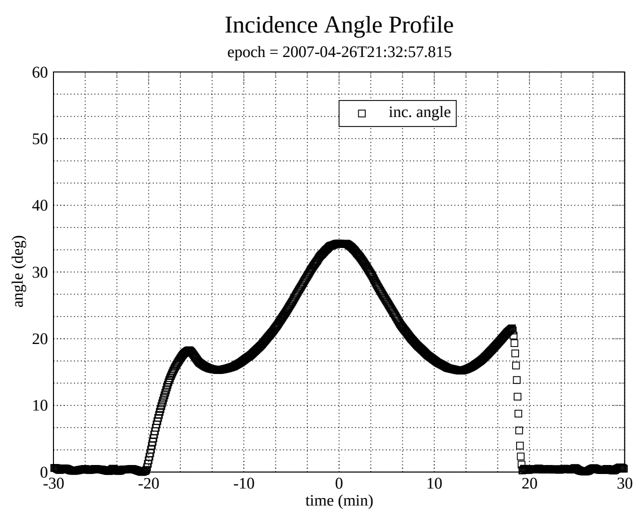

Figure 6: B3 boresight incidence angle during the time around c/a.

Name	Nominal	e	s	Mismatch	Comments
mode	sarh	sarh	sarh	no	
start_time (min)	-6.0	-20.5	18.5	yes	
end_time (min)	6.0	-20.0	19.5	yes	
time_step (s)	don't care	10.0	6.0	no	Set by valid time calculation unless negative, then time_step is used instead
bem	11111	00100	00100	yes	
baq	0	0	0	no	0 - 8 to 2
csr	8	8	8	no	8 - auto gain
noise_bit_setting	3.0	3.4	3.4	yes	
dutycycle	0.70	0.70	0.70	no	
prf (Hz)	don't care	0	0	no	RMSS follows profile
tro	don't care	0	0	no	
number_of_pulses	don't care	0	0	no	RMSS fills round trip time
n_bursts_in_flight	1	1	1	no	
percent_of_BW	100.0	100.0	100.0	no	
auto_rad	off	off	off	no	Set off for SAR modes to allow minimum burst time
rip (ms)	34.0	34.0	34.0	no	Calculated from radiometer calibration for prior observations
max_data_rate	255.000	50.000	50.000	yes	8 to 2 reduces max data rate possible
interleave_flag	on	off	off	yes	
interleave_duration (min)	varies	10.0	12.0	no	

Table 14: t29 Div es standard_sar_hi block

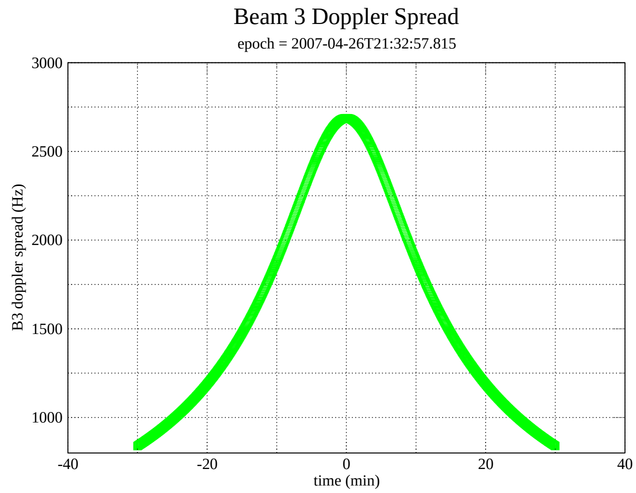

Figure 7: Nadir pointed B3 doppler spread during the time around c/a. Doppler spread is measured within the two-way 3 dB beam pattern.

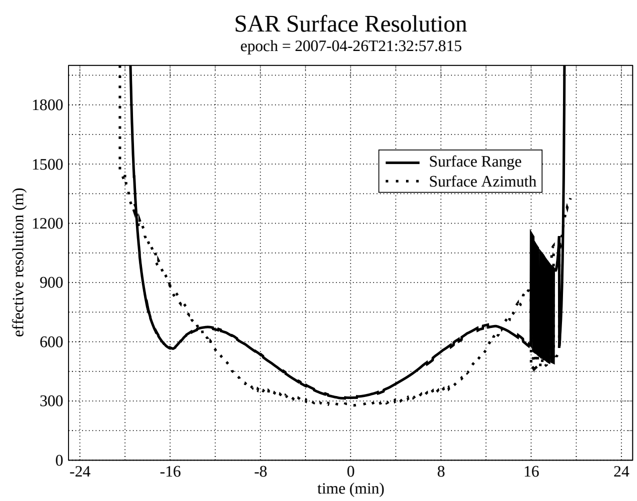

Figure 8: SAR projected range and azimuth resolution. These values are computed from the IEB parameters and are not related to the pixel size in the BIDR file. The pixel size was selected to be always smaller than the real resolution.

Projected range increases with decreasing incidence angle, so the range resolution varies across the swath with better resolution at the outer edge. The SAR pointing profile decreases the incidence angle as time progresses and altitude increases, so there is progressive deterioration of range resolution away from closest approach. The projected range resolution rapidly deteriorates as the incidence angle decreases toward zero at the very beginning and end of the swath.

Azimuth resolution is a function of the synthetic aperture size which is determined by the length of the receive window in each burst (assuming the receive window is always filled with echos). Azimuth resolution deteriorates less quickly because the number of pulses and the length of the receive window are increased as altitude increases which mitigates the increasing doppler bandwidth of the beam patterns. The receive window length increases to fill the round trip time until the science data buffer is filled. At this point it is no longer possible to extend the receive window, and azimuth resolution starts to deteriorate more rapidly.

9 Revision History

1. May 16, 2007: Initial release

10 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI